

Appendix 4-F (Performance Chapter)

Anilox Configuration Data from the Performance Demonstrations

See Site Profiles in Chapter 4 for color sequence.

	Site 1 water-based OPP		Site 2 water-based LDPE, PE/EVA ¹		Site 3 water-based LDPE, PE/EVA ¹		Site 4 water-based OPP		Site 5 solvent-based LDPE, PE/EVA ¹		Site 6 UV LDPE, PE/EVA ¹ , OPP	
	lpi	bcm	lpi	bcm	lpi	bcm	lpi	bcm	lpi	bcm	lpi	bcm
blue	280	7.0	280	6.0	240	7.8	250	6.1	240	4.2	360	4.7
green	280	6.4	300	6.9	240	7.8	250	6.8	240	4.2	360	4.7
white	280	7.5	360	5.0	300	5.2	250	6.3	300	6.2	250	7.5
cyan	800	1.7	360	4.9	500	3.2	800	2.2	550	2.0	600	2.8
magenta	800	1.7	360	5.1	500	3.2	600	2.7	550	2.0	600	2.8

	Site 7 solvent- based LDPE, PE/EVA ¹		Site 8 UV LDPE, PE/EVA ¹ , OPP ²		Site 9A water-based OPP		Site 9B solvent-based OPP		Site 10 solvent-based OPP		Site 11 UV LDPE	
	lpi	bcm	lpi	bcm	lpi	bcm	lpi	bcm	lpi	bcm	lpi	bcm
blue	500	4.0	724	4.5	400	4.0	400	4.0	250	10.1	360	5.6
green	500	4.0	724	4.5	400	4.0	400	4.0	250	9.8	360	5.6
white	200	8.5	200	8.4	300	5.5	300	5.5	250	9.0	300	6.0
cyan	700	2.0	724	4.5	550	2.7	550	2.7	800	1.8	500	2.7
magenta	700	2.0	724	4.5	550	2.7	550	2.7	800	1.6	500	2.7

¹white not used on PE/EVA

²magenta not used on LDPE, OPP

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Appendix 4-G (Performance Chapter)

Surface Tension Data From the Performance Demonstrations

Site	Ink System	Substrates	Surface Tension (dynes)	
			before corona treatment	after corona treatment
Site 1	Water-based	OPP	42	42
Site 2	Water-based	LDPE	39	41
		PE/EVA	40	41
Site 3	Water-based	LDPE	41	41
		PE/EVA	41	41
Site 4	Water-based	OPP	44	44+*
Site 5	Solvent-based	LDPE	42	41
		PE/EVA	42	41
Site 6	UV	LDPE	41	41
		PE/EVA	41	41
Site 7	Solvent-based	LDPE	41	42
		PE/EVA	41	42
Site 8	UV	LDPE	41	42
		PE/EVA	41	41
Site 9A	Water-based	OPP	43	44
Site 9B	Water-based	OPP	43	44
Site 10	Solvent-based	OPP	43	43
Site 11	UV	LDPE	40	40

*dyne pens only go up to 44 dynes

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Appendix 4-H (Performance Chapter)

Viscosity Data From the Performance Demonstrations

Ink System	Film	Product Line Number	Site	Zahn Cup	Color	Viscosity (seconds) at					
						0 minutes	30 minutes	45 minutes	1 hour	1 hour 45 minutes	2 hours
Solvent-based	LDPE	#2	5	#2	blue	19.6	19.4	20.0	21.7	23.1	27.8
					cyan	20.0	21.3	22.0	20.0	19.1	19.4
					green	21.6	24.3	30.0	21.3	22.4	25.6
					magenta	18.0	21.0	21.8	18.7	19.8	21.2
					white	18.4	19.2	23.0	20.3	20.1	21.5
					blue	38.0	26.0	25.0			25.0
					cyan	38.0	30.0	29.0			26.0
	PE/EVA	#2	5	#2	green	38.0	26.0	26.0			20.0
					magenta	38.0	30.0	29.0			28.0
					white	11.0	26.0	27.0			19.0
					blue	19.6	19.4	20.0	21.7	23.1	27.8
					cyan	20.0	21.3	22.0	20.0	19.1	19.4
					green	21.6	24.3	30.0	21.3	22.4	25.6
					magenta	18.0	21.0	21.8	18.7	19.8	21.2
					white	N/A	N/A	N/A	N/A	N/A	N/A
					blue	38.0	26.0	25.0		25.0	
					cyan	38.0	30.0	29.0		26.0	
					green	38.0	26.0	26.0		20.0	
					magenta	38.0	30.0	29.0		28.0	
					white	N/A	N/A	N/A		N/A	

Ink System	Film	Product Line Number	Site	Zahn Cup	Color	Viscosity (seconds) at					
						0 minutes	30 minutes	45 minutes	1 hour	1 hour 45 minutes	2 hours
	OPP	#2	10	#2	blue	41.1	19.7	22.3	22.3	22.0	25.0
					cyan	43.4	34.4	18.8	18.3	18.8	22.0
					green	34.8	25.0	25.0	25.9	25.0	25.0
					magenta	40.9	32.0	18.8	17.8	18.8	18.8
					white		22.2	22.3	23.9	22.2	22.0
Solvent-based	OPP	#4	9B	#2	blue	28.7	33.8	32.5	36.3	40.3	33.4
					cyan	23.5	24.3	24.1	24.1	27.1	27.6
					green	33.1	31.4	30.4	33.8	34.8	29.6
					magenta	31.3	32.5	32.3	37.2	35.1	28.6
					white	31.3	35.7	37.5	31.2	34.9	
Water-based	LDPE	#3	2	#3	blue		12.0	12.0	11.0	11.0	10.0
					cyan		14.0	14.0	16.0	16.0	18.0
					green		14.0	14.0	14.0	14.0	15.0
					magenta		15.0	16.0	17.0	14.0	17.0
					white		16.0	16.0	18.0	19.0	20.0
			3	#2	blue	≥ 90	≥ 90		≥ 90	≥ 90	
					cyan	70.0	75.0		≥ 90	≥ 90	
					green	≥ 90	≥ 90		≥ 90	≥ 90	
					magenta	60.0	65.0		≥ 90	≥ 90	
					white	25.0	27.0		27.0	26.0	

Ink System	Film	Product Line Number	Site	Zahn Cup	Color	Viscosity (seconds) at					
						0 minutes	30 minutes	45 minutes	1 hour	1 hour 45 minutes	2 hours
	PE/EVA	#3	2	#3	blue			15.0		too foamy	
					cyan			25.0		too foamy	
					green			18.0		too foamy	
					magenta			22.0		too foamy	
					white			N/A	N/A	N/A	N/A
			3	#2	blue	≥ 90	≥ 90		≥ 90		≥ 90
					cyan	≥ 90	≥ 90		≥ 90		≥ 90
					green	≥ 90	≥ 90		≥ 90		≥ 90
					magenta	70.0	≥ 90		≥ 90		≥ 90
					white	N/A	N/A		N/A		N/A
Water-based	OPP	#1	4	#2	blue	46.0			34.0		26.0
					cyan	14.0			17.0		15.0
					green	34.0			27.0		24.0
					magenta	14.0			12.0		13.0
					white	37.0			28.0		35.0
		#2	1	#2	blue		17.0	19.0		too foamy	
					cyan		13.0	21.0		too foamy	
					green		15.0			too foamy	
					magenta		11.0	20.0		too foamy	
					white		18.0			too foamy	
		#4	9A	#3	blue	12.1	12.4	12.4	12.0		
					cyan	10.0	10.0	10.0	9.9		
					green	16.1	18.6	13.5	16.1		
					magenta	15.3	14.9	13.4	16.7		
					white	13.1	11.1	11.1	11.1		

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Appendix 4-I (Performance Chapter)

Descriptions and Test Data for Performance Demonstration Sites

PERFORMANCE DEMONSTRATIONS

The inks, substrates, and test plates were shipped to each facility approximately two weeks prior to each test run. The five ink colors were delivered at press in sealed five-gallon containers. A press crew from the facility, and a team from the DfE Project was present at each performance demonstration. The DfE team consisted of John Serafano (WMU), accompanied by one or more individuals from either the DfE staff, WMU, or DfE contractor Abt Associates Inc.

Anilox placement and cylinder mounting were done prior to the arrival of the DfE team. The DfE team and the facility press crews then monitored the press runs, from makeready through clean-up. During each demonstration, the press was run at production speeds (300 to 500 feet per minute) for approximately two hours to produce up to 60,000 feet of printed product (exceptions are described in “Deviations from the Project Methodology”).

During the runs, the necessary data was collected, and on-site tests were conducted. After each run, substrates were shipped to WMU, where more performance testing was conducted.

SITE 1: WATER-BASED INK #2 ON OPP

There was one pre-makeready, one makeready, and one demonstration run performed.

Makeready: OPP

The ink was mixed to the desired viscosity (see Appendix 4-H), and the doctor blade systems were pressurized, delivering ink to the anilox rolls. At this point, the press drive was engaged and the initial running makeready began. Impression was set for each color and registration was achieved. The press speed ranged from 148 to 412 feet per minute (ft/min). Most of the makeready was run on a similar substrate supplied by the site to ensure adequate supply of the control film for the run. A flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample was made. The samples had good lay and trap, there appeared to be no problems with web stability, and there was no evidence of blocking. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.1. The makeready process lasted 64 minutes and consumed 8,975 feet of film. The site-supplied substrate was used first for the makeready, which lasted 27 minutes and consumed 2,783 feet of film. The makeready on the DfE control substrate lasted 37 minutes and consumed 6,192 feet of film.

Table 4-I.1 Results of Tests Performed on OPP at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.590	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.218	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.596	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.500	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: OPP

Viscosity measurements were to have been taken and logged every 15 minutes during the run. However the inks became too foamy, making this impossible. At 30 minutes, the green and white could no longer be measured, and at 45 minutes the blue, cyan, and magenta could no longer be measured. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was initially ramped to 412 ft/min for the demonstration run. It was determined that higher speeds were possible and the speed was increased to 430 ft/min after 10,000 impressions. The run was completed after 129 minutes, with 51,000 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.2.

Table 4-I.2 Results of Tests Performed on OPP at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.64	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.43	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.19	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.53	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

SITE 2: WATER-BASED INK #3 ON LDPE AND PE/EVA

Since the same product line was used for both substrates, only one pre-makeready and one makeready were necessary. However, a “makeready check” was performed at the beginning of the second demonstration run, before the PE/EVA. The only change made between the two demonstration runs was that Deck #1 (white ink) was disengaged because the PE/EVA is a white substrate and white is typically not printed over a white film.

Makeready: LDPE

To ensure adequate substrate supply for the run, a substrate similar to the control was substituted during the makeready.

The ink was mixed to the desired viscosity (see Appendix 4-H), and the doctor blade systems were pressurized, delivering ink to the anilox rolls. At this point, the press drive was engaged and the initial running makeready began. Once impression was set for each color and registration was achieved, the press was ramped up to 118 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed pinholing in all colors. There appeared to be no problems with web stability, and there was no evidence of blocking. The impression was adjusted to correct the pinholing. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted

in Table 4-I.3. The makeready process lasted a total of 40 minutes (25 minutes with in-house substrate, and 15 minutes with DfE substrate), and consumed 6,050 feet of film (4,645 feet of in-house film, and 1,405 feet of DfE film.)

Table 4-I.3 Results of Tests Performed on LDPE at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.46	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.98	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.23	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.74	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Pinholing. Poor trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: LDPE

During the run, viscosity measurements were taken and logged every 15 minutes. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was ramped to 500 ft/min for the demonstration run, but the speed had to be reduced to 403 ft/min because of poor drying and trap. The run was completed after 93 minutes because of an inadequate supply of DfE substrate. 37,053 feet of film were consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.4.

Table 4-I.4 Results of Tests Performed on LDPE at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.592	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.250	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.608	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.594	Pinholing. Poor trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Pinholing. Poor trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: PE/EVA

As stated previously, there was no makeready for the PE/EVA because the press was already set up from the LDPE production run; however, a “makeready check” was performed after 6,000 feet of film were consumed. It was also necessary to disengage Deck #1 (white ink) because the PE/EVA film was white.

The PE/EVA film was mounted on the press unwind reel. The press drive and color decks were engaged and the press was ramped to 403 ft/min where a marker was inserted for sample identification. The press was stopped and a sample was taken for inspection. Density measurements and an adhesiveness test were performed on each color, and a visual quality inspection was made. The results are listed in Table 4-I.5.

Viscosity measurements were taken 15 minutes into the run. Subsequent viscosity measurements were not possible due to foaming of the ink. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

It was necessary to stop the press at 16,000 feet to wipe the plates clean. The run was ended after 37,868 feet of film consumed (102 minutes of run time) in order to match the run length of the LDPE substrate. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.6.

Table 4-I.5 Results of Tests Performed on PE/EVA at End of Makeready

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	1.55	Poor print quality. Trap variable. No problems with dimensional stability or blocking.
Blue	Fail	2.17	Poor print quality. Trap variable. No problems with dimensional stability or blocking.
Magenta	Pass	1.04	Poor print quality. Trap variable. No problems with dimensional stability or blocking.
Cyan	Pass	1.54	Poor print quality. Trap variable. No problems with dimensional stability or blocking.

¹White was not used.

Table 4-I.6 Results of Tests Performed on PE/EVA at End of Run

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	1.25	Poor print quality. Good trap. No problems with dimensional stability or blocking.
Blue	Fail	2.05	Poor print quality. Good trap. No problems with dimensional stability or blocking.
Magenta	Pass	1.16	Poor print quality. Good trap. No problems with dimensional stability or blocking.
Cyan	Pass	1.12	Poor print quality. Good trap. No problems with dimensional stability or blocking.

¹White was not used.

SITE 3: WATER-BASED INK #3 ON LDPE AND PE/EVA

Since the same product line was used for both substrates, only one pre-makeready and one makeready were necessary. However, a “makeready check” was performed at the beginning of the demonstration run for the PE/EVA. Two demonstration runs were performed, one for each substrate. The only change made between the two runs was that Deck #1 (white ink) was disengaged because the PE/EVA is a white substrate.

Makeready: LDPE

The ink was mixed to the desired viscosity (see Appendix 4-H) and the doctor blade systems were pressurized, delivering ink to the anilox rolls. Once impression was set for each color and registration was achieved, the press was ramped up to 250 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed that the lay of the blue over the white was marginal, and the lay of the green over the white was good, but over the film was marginal. The printability of the other colors was good. Trap was acceptable for all colors and there appeared to be no problems with web stability. There was no evidence of blocking. The tape adhesiveness test was conducted, and all colors passed the test, with some light dusting noted on the green and the blue. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.7. The makeready process lasted 63 minutes and consumed 4,220 feet of film. The press was stopped 43 minutes into the makeready, after 3,568 feet of film had been consumed, in order to clean the plates.

Table 4-I.7 Results of Tests Performed on LDPE at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass (light dusting)	1.706	Lay over white is good, over film is marginal. Good trap and dimensional stability. No blocking.
Blue	Pass (light dusting)	2.234	Lay over white is marginal, over film is good. Good trap and dimensional stability. No blocking.
Magenta	Pass	1.676	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.830	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an "at press" test and were measured during the laboratory testing portion of the project.

Demonstration Run: LDPE

Viscosity measurements were attempted, but the viscosity was too high to measure with equipment on site.

The press was initially ramped to 250 ft/min for the demonstration run. There were problems drying the white, and to compensate, the temperature of the dryers was increased. Press speed was reduced to 218 ft/min to improve drying. The run was completed after 126 minutes, with 26,927 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.8.

Table 4-I.8 Results of Tests Performed on LDPE at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass (improved — no dusting)	1.830	Pinholing. Very good trap. No problems with dimensional stability. No blocking.
Blue	Pass (improved — no dusting)	2.022	Pinholing. Very good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.504	Good printability. Very good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.774	Good printability. Very good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Very good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: PE/EVA

As stated previously, there was no makeready for the PE/EVA because the press was already set up from the LDPE production run, but a “makeready check” was performed. It was necessary to disengage Deck #1 (white ink) because the PE/EVA film was white.

The PE/EVA film was mounted on the press unwind reel. The press drive and color decks were engaged and the press was ramped to 350 ft/min. The speed was increased to 430 ft/min. During the run, 6,300 feet of film were consumed. The demonstration team noted that there was a problem with the gearing on the magenta ink station which was causing poor register.

APPENDIX 4-I DESCRIPTIONS AND TEST DATA FOR PERFORMANCE DEMONSTRATION SITES

A marker was inserted for sample identification. The press was stopped and a sample was taken for inspection. Density measurements and an adhesiveness test were performed on each color, and a visual quality inspection was also made. The results are listed in Table 4-I.9.

Viscosity measurements were attempted but the viscosity was too high and over the recommended range of the viscosity cup. See Appendix 4-H for the full data table of viscosity measurements.

The run was completed after 131 minutes, with 47,884 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.10.

Table 4-I.9 Results of Tests Performed on PE/EVA at End of Makeready

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass (light dusting)	1.606	Poor wetting of green on white. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass (light dusting)	2.028	Pinholing of blue on white. Good trap. No problems with dimensional stability or blocking.
Magenta	Pass	1.342	Good printability and trap. No problems with dimensional stability or blocking.
Cyan	Pass	1.534	Good printability and trap. No problems with dimensional stability or blocking.

¹White was not used.

Table 4-I.10 Results of Tests Performed on PE/EVA at End of Run

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	1.440	Increased pinholing. Good trap. No problems with dimensional stability. No blocking.
Blue	Fail	1.768	Increased pinholing. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.256	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.384	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹White was not used.

SITE 4: WATER-BASED INK #1 ON OPP

There was one pre-makeready, one makeready, and one demonstration run performed.

Makeready: OPP

The ink was mixed to the desired viscosity (see Appendix 4-H) and the doctor blade systems were pressurized, delivering ink to the anilox rolls. At this point, the press drive was engaged and the initial running makeready began. The start of the makeready was run on a site-supplied substrate similar to the DfE control film.

The press achieved an optimal speed of 200 ft/min, and it was stopped twice during the makeready due to low printed opacity. The first time the press was stopped (after running for 14 minutes) was to replace the white ink. It was determined that the first white ink used had a very low percentage of solids. It was replaced with another ink of the same type which had a higher percentage of solids. Changing the ink did not adequately correct the low opacity. The press was stopped a second time (after running for 11 more minutes) to replace the white anilox roll, again in an effort to improve opacity. The press crew and DfE team decided to continue despite low opacity.

Once impression was set for each color and registration was achieved, a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed slight pinholing of the green over the white, and moderate pinholing of the blue over the white. All other ink colors achieved good printability. Trap was acceptable and there appeared to be no problems with web stability. There was no evidence of blocking. The impression was adjusted in an effort to correct pinholing. The tape adhesiveness test was conducted, and all colors passed the test except cyan. The failure of the cyan was thought to be due to the foaminess of the ink, but was not proven. Alcohol was added in an effort to reduce the foam. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.11.

The makeready process lasted 136 minutes (45 minutes of actual press run time, and 91 minutes of down time for problems noted previously) and consumed 6,600 feet of film.

Table 4-I.11 Results of Tests Performed on OPP at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.962	Slight pinholing over white. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.114	Moderate pinholing over white. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.358	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Fail (possibly due to foam; alcohol was added to reduce foam)	1.448	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: OPP

During the run, viscosity measurements were taken and logged every 60 minutes. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was initially ramped to 400 ft/min for the demonstration run. The speed was then increased to 450 ft/min, after 7,500 feet of film had been consumed. Press speed was later slowed to 435 ft/min, and then to 415 ft/min for the last roll of substrate because of drying concerns. Samples printed at the last three speeds were used for the performance tests. The run was completed after 123 minutes, with 13,160 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.12.

Table 4-I.12 Results of Tests Performed on OPP at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.930	Increased pinholing. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.152	Plugging and pinholing. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.328	Slight pinholing. Good trap. No problems with dimensional stability. No blocking.
Cyan	Fail, but improved	1.174	Slight pinholing. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Slight pinholing. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

SITE 5: SOLVENT-BASED INK #2 ON LDPE AND PE/EVA

Since the same product line was used for both substrates, only one pre-makeready and one makeready were necessary. However, a “makeready check” was performed at the beginning of the second demonstration run, the one for the PE/EVA. Two demonstration runs were performed, one for each substrate. The only change made between the two runs was that Deck #1 (white ink) was disengaged because the PE/EVA is a white substrate.

Makeready: LDPE

The ink was mixed to the desired viscosity (see Appendix 4-H) and the doctor blade systems were pressurized, delivering ink to the anilox rolls. Once impression was set for each color and registration was achieved, the press was ramped up to 400 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed pinholing on the operator side of the image in the green and blue solid blocks. Trap was acceptable and there appeared to be no problems with web stability. There was no evidence of blocking. The impression was adjusted to correct the pinholing. The tones were inspected for cleanliness and transfer.

Solvent was added as needed to adjust viscosity in each of the colors to improve printability. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.13. The makeready process lasted 59 minutes and consumed 1,933 feet of film.

Table 4-I.13 Results of Tests Performed on LDPE at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.590	Pinholing on one side. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.218	Pinholing on one side. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.596	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.500	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹ The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: LDPE

During the run, viscosity measurements were taken and logged every 15 minutes, with solvent and ink additions noted at each occurrence. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was ramped to 400 ft/min for the demonstration run, and the run was completed after 57 minutes, with 21,924 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.14.

Table 4-I.14 Results of Tests Performed on LDPE at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.592	Pinholing on one side. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.250	Plate contamination. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.608	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.594	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: PE/EVA

As stated previously, there was no makeready for the PE/EVA because the press was already set up from the LDPE production run. It was necessary to disengage Deck #1 (white ink) because the PE/EVA film was white.

The press drive and color decks were engaged and the press was ramped to 400 ft/min where a marker was inserted for sample identification. The press was stopped and a sample was taken for inspection. Density measurements and an adhesiveness test were performed on each color, and a visual quality inspection was made. The results are listed in Table 4-I.15.

During the run, viscosity measurements were taken and logged every 15 minutes, with solvent and ink additions noted at each occurrence. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The run was completed after 56 minutes, with 20,858 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.16.

Table 4-I.15 Results of Tests Performed on PE/EVA at End of Makeready

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.31	Good printability and trap. No problems with dimensional stability or blocking.
Blue	Pass	1.72	Good printability and trap. No problems with dimensional stability or blocking.
Magenta	Pass	1.51	Good printability and trap. No problems with dimensional stability or blocking.
Cyan	Pass	1.46	Good printability and trap. No problems with dimensional stability or blocking.

¹White was not used.

Table 4-I.16 Results of Tests Performed on PE/EVA at End of Run

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.51	Uneven impression in the trap. No problems with dimensional stability or blocking.
Blue	Pass	1.94	Uneven impression in the trap. No problems with dimensional stability or blocking.
Magenta	Pass	1.21	Tones plugging. Uneven impression in the trap. No problems with dimensional stability or blocking.
Cyan	Pass	1.57	Tones plugging. Uneven impression in the trap. No problems with dimensional stability or blocking.

¹White was not used.

SITE 6: UV INK #2 ON LDPE, PE/EVA, AND OPP

Since the same product line was used for all three substrates, only one pre-makeready and one makeready were necessary. However, a “makeready check” was performed at the beginning of the second demonstration run, for the PE/EVA, and the third, for the OPP. The only change made between the demonstration runs was that Deck #1 (white ink) was disengaged to run the PE/EVA, because it is a white substrate, and re-engaged to run the clear OPP substrate.

Makeready: LDPE

Viscosity measurements were not taken for UV inks at press because of the thixotropic nature of the inks. Once impression was set for each color and registration was achieved, the press was ramped up to 310 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed slight pinholing in the white, the print quality appeared dirty, and there was evidence of plate contamination. There was acceptable printability in all other colors. Some wrinkling of the substrate was noted and attributed to the heat of the UV lamps. Trap was acceptable and there was no evidence of blocking. The impression was adjusted to correct the pinholing. The tones were inspected for cleanliness and transfer. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.17. The makeready process lasted 80 minutes and consumed 3,964 feet of film.

Table 4-I.17 Results of Tests Performed on LDPE at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.54	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
Blue	Pass	2.15	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
Magenta	Pass	1.75	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
Cyan	Pass	1.45	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
White	Pass	Not measured ¹	Pinholing. Dirty printing. Plate contamination. Good trap. Some wrinkling of substrate from heat. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: LDPE

Viscosity measurements were not taken for the UV inks, and no adjustments were made to the inks.

The press was ramped to 338 ft/min for the first roll of LDPE for the demonstration run, and 351 ft/min for the second roll. The run was completed after 92 minutes, with 32,431 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.18. The LDPE film was unmounted in preparation for the PE/EVA run.

Table 4-I.18 Results of Tests Performed on LDPE at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.46	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
Blue	Pass	2.10	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
Magenta	Pass	1.77	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
Cyan	Pass	1.50	Good printability. Good trap. Some wrinkling of substrate from heat. No blocking.
White	Pass	Not measured ¹	Pinholing. Dirty printing. Plate contamination. Good trap. Some wrinkling of substrate from heat. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: PE/EVA

As stated previously, there was no makeready for the PE/EVA because the press was already set up from the LDPE production run, however a “makeready check” was performed. It was necessary to disengage Deck #1 (white ink) because the PE/EVA film was white.

The PE/EVA film was mounted on the press unwind reel. The press drive and color decks were engaged and the press was ramped to 354 ft/min where a marker was inserted

APPENDIX 4-I DESCRIPTIONS AND TEST DATA FOR PERFORMANCE DEMONSTRATION SITES

for sample identification. The press was stopped and a sample was taken for inspection. Density measurements and an adhesiveness test were performed on each color, and a visual quality inspection was made. The results are listed in Table 4-I.19.

Again, viscosity measurements were not taken for the UV inks, and no adjustments were made to the inks.

Table 4-I.19 Results of Tests Performed on PE/EVA at End of Makeready “Check”

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	1.41	Good ink lay. Dirty printing. Fair trap. No problems with dimensional stability or blocking.
Blue	Fail	2.14	Good ink lay. Dirty printing. Fair trap. No problems with dimensional stability or blocking.
Magenta	Fail	1.26	Good ink lay. Dirty printing. Fair trap. No problems with dimensional stability or blocking.
Cyan	Fail	1.54	Good ink lay. Dirty printing. Fair trap. No problems with dimensional stability or blocking.

¹White was not used.

The run was completed after 95 minutes, with 27,691 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.20.

Table 4-I.20 Results of Tests Performed on PE/EVA at End of Run

Ink Color ¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	1.43	Good ink lay. Dirty printing. Good trap. No problems with dimensional stability or blocking.
Blue	Fail	1.92	Good ink lay. Dirty printing. Good trap. No problems with dimensional stability or blocking.
Magenta	Fail	1.53	Good ink lay. Dirty printing. Density high — unable to reduce. Good trap. No problems with dimensional stability or blocking.
Cyan	Pass	1.53	Good ink lay. Dirty printing. Good trap. No problems with dimensional stability or blocking.

¹White was not used.

Demonstration Run: OPP

As stated previously, there was no makeready for the OPP because the press was already set up from the PE/EVA production run, however a “makeready check” was performed. Deck #1 (white ink) was re-engaged because the OPP film was a clear film.

The press drive and color decks were engaged and the press was ramped to 344 ft/min where a marker was inserted for sample identification. The press was stopped and a sample was taken for inspection. Density measurements and an adhesiveness test were performed on each color, and a visual quality inspection was made. The results are listed in Table 4-I.21.

Viscosity measurements were not taken for the UV inks, and no adjustments were made.

The run was stopped prematurely due to overheating of the chill roller by the UV lamp. This occurred after 38 minutes of run time, with 6,583 feet of film consumed. No samples were taken, and no measurements made for the end of the run, as shown in Table 4-I.22.

Table 4-I.21 Results of Tests Performed on OPP at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	0.60	Good printability. Fair trap. No problems with dimensional stability or blocking.
Blue	Fail	0.65	Good printability. Fair trap. No problems with dimensional stability or blocking.
Magenta	No data	1.51	Good printability. Fair trap. No problems with dimensional stability or blocking.
Cyan	Fail	1.32	Good printability. Fair trap. No problems with dimensional stability or blocking.
White	Fail	Not measured ¹	Pinholing. Dirty printing. Low opacity on visual inspection. Fair trap. No problems with dimensional stability or blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Table 4-I.22 Results of Tests Performed on OPP at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	n/a	n/a	No samples taken — run stopped prematurely due to overheating of chill roller by UV lamp.
Blue	n/a	n/a	No samples taken — run stopped prematurely due to overheating of chill roller by UV lamp.
Magenta	n/a	n/a	No samples taken — run stopped prematurely due to overheating of chill roller by UV lamp.
Cyan	n/a	n/a	No samples taken — run stopped prematurely due to overheating of chill roller by UV lamp.
White	n/a	n/a	No samples taken — run stopped prematurely due to overheating of chill roller by UV lamp.

SITE 7: SOLVENT-BASED INK #2 ON LDPE AND PE/EVA

Makeready: LDPE

The ink was mixed to the desired viscosity (see Appendix 4-H) and the doctor blade systems were pressurized, delivering ink to the anilox rolls. After the press drive was engaged, the makeready began. Once impression was set for each color and registration was achieved, the press was ramped up to 450 ft/min. There was a web break 35 minutes into the makeready due to press and operator conditions.

A visual inspection of the makeready sample revealed that the printing quality of the tones appeared dirty, but the lay was good, trap was very good, and there appeared to be no problems with web stability. There was also no evidence of blocking. The demonstration team noted that the ink looked “a little too fast” (in the ink appeared to be drying on the plate).

The tones were inspected for cleanliness and transfer. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.23. The makeready process lasted 58 minutes and consumed 2,350 feet of film.

Table 4-I.23 Results of Tests Performed on LDPE at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	0.988	“Dirty” printing in tones on one side. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.784	“Dirty” printing in tones on one side. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.406	“Dirty” printing in tones on one side. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.264	“Dirty” printing in tones on one side. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	“Dirty” printing in tones on one side. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: LDPE

During the run, viscosity measurements were taken and logged at 15, 30, and 120 minutes into the run. Markers were used to identify the timed locations of start, 30 minutes, and

end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was ramped to 450 ft/min for the demonstration run, and the run was completed after 148 minutes, with 42,000 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.24.

Table 4-I.24 Results of Tests Performed on LDPE at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	0.840	Tones improved. Mottle/lay good. Very good trap. No blocking. No problems with dimensional stability.
Blue	Pass	1.742	Tones improved. Mottle/lay good. Very good trap. No blocking. No problems with dimensional stability.
Magenta	Pass	1.302	Tones improved. Mottle/lay good. Very good trap. No blocking. No problems with dimensional stability.
Cyan	Pass	1.150	Tones improved. Mottle/lay good. Very good trap. No blocking. No problems with dimensional stability.
White	Pass	Not measured ¹	Tones improved. Mottle/lay good. Very good trap. No blocking. No problems with dimensional stability.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: PE/EVA

As stated previously, it was intended that the PE/EVA substrate also be run at this location. The substrate was mounted on the press, and the “makeready check” was begun. After only 8,069 feet of film were consumed, the run was aborted. The demonstration team decided that the roll of substrate they were running was not the correct project control film, due to a supplier mix-up. In addition, the substrate had wrinkles from poor extrusion, the cores were not the correct size, and the cores were crushed.

No samples were taken from the PE/EVA run, and no measurements made.

SITE 8: UV INK #3 ON LDPE, PE/EVA, AND OPP

The PE/EVA substrate (a white substrate) was run first, followed by the LDPE, and finally the OPP. Since this was run on a four-color press, it was necessary to make a complete change on Deck #1 between the PE/EVA and LDPE substrates, changing from magenta ink and a process plate, to white ink and a line plate. No change was necessary between the LDPE and the OPP. There was only one pre-makeready, and the makeready was performed before the demonstration team arrived at the plant for the run. There were no “makeready checks” performed when the substrates were changed.

Makeready: PE/EVA

The makeready was performed before the demonstration team arrived. The press crew reported that the makeready took between 60 and 120 minutes, achieved a press speed of 262 ft/min, and consumed 800 feet of film.

Two samples were taken from the roll for analysis. A visual inspection revealed that the print quality of the green was good, and the quality of the process tones was excellent. It was noted, however, that the print quality of the blue solid appeared dirty. The trap was very good, there appeared to be no problems with web stability, and there was no evidence of blocking. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.25.

Table 4-I.25 Results of Tests Performed on PE/EVA at End of Makeready

Ink Color¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.066	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.200	Dirty printing. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.150	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.312	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹White was not used.

Demonstration Run: PE/EVA

No viscosity measurements were taken on the UV inks during the run. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure.

The press was ramped to 262 ft/min for the demonstration run, and the run was completed after 63 minutes, with 15,912 feet of film consumed. A sample was taken at the end of the run for density measurements, and visual quality inspection. The results are listed in Table 4-I.26.

Table 4-I.26 Results of Tests Performed on PE/EVA at End of Run

Ink Color ¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.096	Dirty printing. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.280	Dirty printing in solid. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.332	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.410	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹White was not used.

Demonstration Run: LDPE

As stated previously, Deck #1 was changed from magenta to white ink, and the plate was also changed from a process plate to a line plate. No “makeready check” was performed.

The press drive and color decks were engaged and the press was ramped to 262 ft/min. The run was completed after 65 minutes, with 2,559 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.27. The LDPE film was unmounted in preparation for the OPP run.

No viscosity measurements were taken of the UV inks during the run. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure.

Table 4-I.27 Results of Tests Performed on LDPE at End of Run

Ink Color ¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	0.994	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Fail	0.976	Dirty printing in solid. Good trap. No problems with dimensional stability. No blocking.
Cyan	Fail	1.136	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Fail	Not measured ²	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹Magenta was not used.

²The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: OPP

As stated previously, no “makeready check” was performed for the OPP.

A limited amount of OPP was available due to shipping concerns between the U.S. and Germany. The OPP film was mounted on the press unwind reel. The press was ramped to 262 ft/min. The run was completed after 15 minutes, with 4,265 feet of film consumed. The run was shortened due to the limited quantity of OPP. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.28.

No viscosity measurements were taken during the run. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure.

Table 4-I.28 Results of Tests Performed on OPP at End of Run

Ink Color ¹	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Fail	1.058	Slight dirty printing. Good trap. No problems with dimensional stability. No blocking.
Blue	Fail	1.116	Dirty printing. Good trap. No problems with dimensional stability. No blocking.
Cyan	Fail	1.174	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Fail	Not measured ²	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹Magenta not used.

²The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

SITE 9A: WATER-BASED INK #4 ON OPP

One pre-makeready, one makeready, and one demonstration run were performed.

Makeready: OPP

The ink was mixed to the desired viscosity (see Appendix 4-H) and the doctor blade systems were pressurized, delivering ink to the anilox rolls. Once impression was set for each color and registration was achieved, the press was ramped up to 680 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed very good printability. Trap was acceptable and there appeared to be no problems with web stability. There was no evidence of blocking. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.29. The makeready process lasted 120 minutes and consumed 1,250 feet of film.

Table 4-I.29 Results of Tests Performed on OPP at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.422	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.064	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.434	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.710	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: OPP

During the run, viscosity measurements were taken and logged every 15 minutes. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was ramped to 425 ft/min for the demonstration run, and the run was completed after 66 minutes, with 34,434 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.30.

Table 4-I.30 Results of Tests Performed on OPP at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.494	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.068	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.460	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.756	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

SITE 9B: SOLVENT-BASED INK #4 ON OPP

There was one pre-makeready, one makeready, and one demonstration run performed.

Makeready: OPP

The ink was mixed to the desired viscosity (see Appendix 4-H) and the doctor blade systems were pressurized, delivering ink to the anilox rolls. Once impression was set for each color and registration was achieved, the press was ramped up to 680 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed poor printability in the blue, and acceptable printing in the other colors. It was suggested by the demonstration team and press crew that the blue ink and doctor blade be replaced. After the changes were made, trap was acceptable and there appeared to be no problems with web stability. There was no evidence of blocking. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.31. The makeready process lasted 135 minutes and consumed 1,930 feet of film.

Table 4-I.31 Results of Tests Performed on OPP at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.074	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.686	Poor printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.286	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.534	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: OPP

During the run, viscosity measurements were taken and logged every 15 minutes. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was ramped to 415 ft/min for the demonstration run, and the run was completed after 80 minutes, with 33,641 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.32.

Table 4-I.32 Results of Tests Performed on OPP at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.062	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.730	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.568	Good printability. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.870	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

SITE 10: SOLVENT-BASED INK #2 ON OPP

One pre-makeready, one makeready, and one demonstration run was performed.

Makeready: OPP

The ink was mixed to the desired viscosity (see Appendix 4-H). Once impression was set for each color and registration was achieved, the press was ramped up to 800 ft/min and a flag was inserted to mark a print for inspection.

The press was stopped after insertion of the marker and two samples were taken for analysis. A visual inspection of the makeready sample revealed poor solid formation in the magenta, with good printability in all other colors. Trap was acceptable and there appeared to be no problems with web stability.

There was no evidence of blocking. The press crew and demonstration team felt that the problem with the magenta was due to the system being too fast, so slow solvent was added to the red ink fountain to compensate. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull. The results of the visual inspection are noted in Table 4-I.33. The makeready process lasted 120 minutes and consumed 10,950 feet of film.

Table 4-I.33 Results of Tests Performed on OPP at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.35	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.93	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	0.81	Poor solid formation. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.03	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: OPP

During the run, viscosity measurements were taken and logged every 15 minutes. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure. See Appendix 4-H for the full data table of viscosity measurements.

The press was ramped to 600 ft/min for the demonstration run, and the run was completed after 90 minutes, with 56,700 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.34.

Table 4-I.34 Results of Tests Performed on OPP at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.36	Good printability. Good trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.83	Good printability. Good trap. No problems with dimensional stability. No blocking.
Magenta	Pass	0.85	Still poor solid formation. Good trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.10	Good printability. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Good trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

SITE 11: UV INK #1 ON LDPE (NO SLIP)

One pre-makeready, one makeready, and one demonstration run was performed.

Makeready: LDPE

Once impression was set for each color and registration was achieved, the press was ramped up to 700 ft/min and a flag was inserted to mark a print for inspection.

A visual inspection of the makeready sample revealed good ink lay in all colors, however there was blade streaking in the cyan image. There was also dry ink on the blue anilox roller. Trap was fair, and there were no problems with dimensional stability. There was no evidence of blocking. The tape adhesiveness test was conducted, and all colors passed the test. Density measurements were taken and recorded on each color of the sample pull.

The results of the visual inspection are noted in Table 4-I.35. The makeready process lasted 75 minutes and consumed 7,200 feet of film.

Table 4-I.35 Results of Tests Performed on LDPE at End of Makeready

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.408	Good printability. Fair trap. No problems with dimensional stability. No blocking.
Blue	Pass	1.792	Good printability. Fair trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.074	Good printability. Fair trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.036	Good printability, with blade streaking. Fair trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Fair trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Demonstration Run: LDPE

Viscosity measurements were not taken for the UV inks, and no adjustments were made to the inks. Markers were used to identify the timed locations of start, 30 minutes, and end of the run within the rolls for sample removal during the laboratory testing procedure.

The press was ramped to 400 ft/min for the demonstration run, and the run was completed after 153 minutes, with 38,400 feet of film consumed. A sample was taken at the end of the run for density measurements, adhesiveness tests, and visual quality inspection. The results are listed in Table 4-I.36.

Table 4-I.36 Results of Tests Performed on LDPE at End of Run

Ink Color	Tape Adhesiveness Test (pass / fail)	Density [unitless] (average of five measurements)	Visual Quality
Green	Pass	1.495	Good printability. Fair trap. No problems with dimensional stability. No blocking.
Blue	Pass	2.170	Good printability. Fair trap. No problems with dimensional stability. No blocking.
Magenta	Pass	1.093	Good printability. Fair trap. No problems with dimensional stability. No blocking.
Cyan	Pass	1.248	Good printability, with blade streaking. Good trap. No problems with dimensional stability. No blocking.
White	Pass	Not measured ¹	Good printability. Fair trap. No problems with dimensional stability. No blocking.

¹The white ink was not measured for density because the efficiency of white ink is measured by an opacity test. Opacity measurements are not typically an “at press” test and were measured during the laboratory testing portion of the project.

Appendix 4-J (Performance Chapter) Descriptions and Performance Test Data for the Laboratory Runs

Pre-makeready

Plates, substrates, and inks were delivered to the facility approximately two weeks prior to the print run. Each of the ink colors was delivered at press in sealed five-gallon containers. Anilox placement and cylinder mounting were done by the laboratory personnel.

Makeready

The inks were reduced to 25 seconds using a Zahn cup. The press was ramped up to its optimal speed for the ink/substrate combination. Two samples were collected for inspection to verify optimum conditions.

Laboratory Runs

A total of seven laboratory runs were conducted.

Printing viscosities were maintained at 25 seconds using a Zahn #2 efflux cup, for all colors on all runs. Since these press runs were performed at Western Michigan University (WMU), all performance testing was conducted after completion of the runs. The results of the tape adhesiveness test, density measurements, and visual quality inspection for each print run are listed in Table 4-J.1. The dryer temperatures are listed in Table 4-J.2.

Table 4-J.1. Performance Test Results (At Press) of Laboratory Runs

Run	Ink Color	Scotch Tape Adhesiveness Test (Pass / Fail)	Density	Opacity	Visual Quality
L1	Green	P	0.95		mottled, poor wetting, weak color
	White	P		43%	pinholing
L2	Green	F	0.99		slightly mottled, color weak
	White	P		29%	pinholing, low opacity
L3	Green	P	0.70		color weak, slight mottle
	White	P		37%	low opacity
L4	Green	P	0.72		weak color, slight mottle
	White	P		38%	acceptable coverage
L5	Green	P	0.90		slight mottle
	White	P		54%	good opacity coverage
L6	Green	F	0.90		mottle, poor coverage
	Cyan	F	1.09		slight mottle
L7	Green	P	1.12		good color and coverage
	Cyan	P	1.30		slight mottle

Table 4-J.2. Dryer Temperatures for Laboratory Runs

Run	Temperature Deck #1 (°F)	Temperature Deck #2 (°F)
L1	162	145
L2	170	165
L3	160	155
L4	120	110
L5	122	118
L6	162	160
L7	125	120

Appendix 4-K (Performance Chapter)

Performance Test Data from Laboratory Runs for Inks Not Used in the Performance Demonstrations

Five ink manufacturers submitted six product lines to be tested in the lab that were not printed at the performance demonstration sites. The lines were as follows:

(Ink manufacturer #1)	1 solvent product line – cyan, 354 green, and white
(Ink manufacturer #2, #3)	3 water product lines – cyan, 354 green, and white <i>ink manufacturer #3 supplied two product lines, one for lamination and one for surface printing</i>
(Ink manufacturer #4, #5)	2 UV product lines – cyan, 354 green and white <i>the UV product lines were not printed due to lack of equipment capabilities on the lab press</i>

The following is used to identify the ink product lines:

IM #1 - PE
IM #1 - EVA
IM #2 - EVA
IM #2 - PE
IM #3 - EVA
IM #3 - PE
IM#3L - OPP
IM #4 - not run
IM #5 - not run

Ink sets #1, #2, and #3 were printed as two press runs listed below:

Run A - Deck #1 220 anliox white ink and, Deck #2 440 anilox cyan ink (two colors)
Run B - Deck #2 440 anliox 354 green (one color)

A combination plate containing both line and half tones was used for both the 354 green and cyan color inks in Deck #2.

Only run IM#3L was printed with the OPP substrate since this product line was specified as a lamination ink. IM #1, IM#2 and IM#3 was printed with both LDPE and LDPE/EVA substrates. IM #4 and IM #5 were not printed.

All inks were reduced to 25 seconds #2 Zahn cup. Each set was printed for 3 to 5 minutes to stabilize the press conditions and obtain registration. The dryers were set to 140° F. All inks dried adequately at speed up to 350 ft/min.

APPENDIX 4-K PERF. TEST DATA FROM LAB RUNS FOR INKS NOT USED IN PERF. DEMOS

Table 4-K reports the qualitative performance of each ink. Each ink was evaluated for scotch tape adhesion, and general visual print quality.

Table 4-K Qualitative Performance of Inks Not Used in Performance Demonstrations

Product Line	Tape Adhesion Test	Visual Quality
IM #1 - PE Cyan & White	pass all colors	white opacity low; slight mottle; no pinholing; trap acceptable
IM #1 - EVA Green	pass all colors	slight mottle all colors; trap acceptable
IM #2- PE Cyan & White	pass all colors	mottle in cyan from poor wetting, pinholing in cyan and white; cyan color weak; poor wetting and trap
IM #2 - EVA Green	pass all colors	slight mottle;. no pinholing
IM #3 - PE Cyan & White	pass all colors	slight mottle all colors; trap good; slight pinholing; color good
IM #3 - EVA Green	pass all colors	slight mottle all colors; no pinholing
IM #3L - OPP Cyan & White	pass all colors	slight mottle all colors; trap acceptable; no pinholing